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National Aeronautics and Space Administration
Biotechnology and Human Research
Washington 25, D. C.

Attention: Mr. George Chatham

Reference: Review of Biological Mechanisms for Application to
Instrument Design
ARA Project No. 9211

Subject: (Contract NASw-535 extension
Third Quarterly Report)

Gentlemen:

This letter report is a resume of the work performed during the third three months of NASA Contract NASw-535 extension. The literature search is being currently updated.

Electric Field Sensors

Examples of electric field sensors are becoming more numerous with the increasing amount of research being done in this area. In addition to the Franz protuberances in Mormyridae identified by Szabo and other suggested electroreceptors such as Savi's vesicles of Torpedo, "pit organs" of catfish. Dykgraaf in 1964 in behavioral experiments with Scyborhius canicula showed that the ampullae of Lorenzini are utilized as electroreceptor capabilities (electric field sensing) exist in a wide range of biological organisms, both plant and animal. For example, Troutman and Wills observed when free-swimming zoospores of Phytophthora parasitica were subjected to an electric current they always migrated toward

the negative electrode. These zoospores also collect in the zone just back of the root cap. Apparently, they are directed to certain areas of a root surface by weak electric currents and attachment of the spores by their flagellae to these root surfaces is effected by electrostatic forces. Plant roots produce weak electric currents and possess areas of different surface charge. The exact mechanism by which these zoospores are effected by electric field forces has not been elucidated.

The clarification of the mechanisms responsible for electric field sensitivity in living organisms could have application to a number of detection systems. The development of underwater detection devices which could detect missile-carrying nuclear submarines, etc. would be one such application. Such a device could consist of a battery of electrotransducers which operate in a manner similar to Franz protuberances which act as electroreceptors for the Mormyridae and detect form and distance. A detection device could then relay such information to a read-out center programmed directly to a retaliatory force.

Chemoreceptors

Olfaction

In addition to the extension of the investigation into the applicability of liquid crystals as sensors, considerable emphasis during this quarter has been placed on chemoreceptor response in insects and other arthropods, many of which have fantastically low thresholds of sensitivity for certain chemical stimuli and which are highly specific. A well-known example is the carrion beetle of the genus Necrophorus. Necrophorus receptor units react to odor currents of decomposing meat and certain chemically defined related substances such as mercaptan but are unresponsive to various other compounds such as ammonia and H_2O . Artificial sensing devices which are highly responsive to only certain specified chemicals are needed for a variety of detection or monitoring situations.

Additional time was spent investigating the olfactory sense of birds. This field, due to experimental difficulties, has not received sufficient

emphasis in the past. Neuhaus has done some interesting work with greylag goose [Anser anser L] on spontaneous responses to odor utilizing respiration patterns which were recorded.

Notice was made of the work investigating the role that olfactory responses, involving odor memory, play in the orientation of fish. Experiments conducted by Collins on the alewife (Pomolobus) proved that differences in carbon dioxide tension play an important role in the migration behavior of fish.

Further recent work by Hasler point out that a 'home' odor plays an important part in fish orientation. A device responsive to certain chemical molecules would be valuable as an extremely sophisticated navigational aid.

Photoreceptors

A comparative study of the various forms of light receptors in the animal kingdom was continued. Photoreception plays a significant role in orienting the growth or locomotion of plants and animals. For example, in the aquatic insect, Ranatra, if the left eye received more light than the right eye, the legs on the left side of the body will be more strongly flexed, whereas the legs on the right side of the body will be extended to a greater degree and will make longer sweeps. As the animal swims in this posture, it will tend to turn toward the source of light.

Many aquatic animals show some activity response to the increase or decrease of light at extremely low intensities. Studies of the diurnal vertical migration of Zooplankton indicate that certain species may react to light from the surface at depths of 800 meters and possible at 1000 meters.

Further investigations concerned themselves with the phenomena of Lunar periodicity as exemplified by the grunion, palolo worm, etc. Since the intensity of full moonlight is more than 10^{-6} of noon sunlight, light at these depths is well above the threshold of perception of many organisms.

Thermoreceptors

Interest in the preceding quarter in this area was centered on the peripheral temperature receptors and central temperature "detectors" that participate in the regulation of mammalian body temperatures. Cutaneous thermoreceptors in lower life forms are being reviewed.

Mechanoreceptors

A comparative investigation of vertebrate otoliths was reviewed during the past quarter. The mechanisms of orientation sensing and acceleration detection in both mammalian and non-mammalian organisms were compared with particular emphasis.

It is hoped that an increased understanding of this mechanism and its response to unusual situations and its integrated role in behavioral regulation will ultimately lead to the development of new systems or techniques for providing a stabilization or directional sense where environmental conditions preclude the standard inputs to these sensors.

Program Personnel

The rate of effort of members of the staff who worked on the contract during the period covered by this report is as follows:

J. Healer, Bioscientist	40.8%
M. Messer, Bioscientist	20%
F. Bird, Senior Engineer	5%

Very truly yours,

ALLIED RESEARCH ASSOCIATES, INC.


Janet Healer
Project Scientist

JH:sh